IMPROVED CLEANING METHODS FOR PLANETARY PROTECTION BIOBURDEN REDUCTION

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Planetary protection requirements for landed missions to Mars dictate that flight hardware have a bioburden level no greater than 300 spores/m^2 (Category IVA). A more rigorous bioburden requirement of 30 viable organisms/landed event (Category IVB) is currently levied on any Mars Sample Return (MSR) mission, with the additional requirement to limit organic contamination (levels TBD) on those components of the flight hardware that come into direct contact the sample (Category V). The current, accepted method for cleaning hardware uses either ethanol or 70% isopropyl alcohol (IPA) on a cleanroom wipe. Past studies in our Group have shown that for aluminum inoculated with a known bioburden, wiping with 70% IPA leads to the lyses of selected Gram-positive and Gram-negative bacteria, with the additional effect of adhering whole cells and/or bioremnants to the surface.

Our Group is now conducting a detailed study into the biological cleaning effectiveness of a series of cleaning methods. For the purposes of the current study, biological cleaning effectiveness is defined in terms of the ability to remove viable spores. In the study, coupons of two flight hardware materials, Al 6061 (mill finish 15 rms) and Ti 6Al-4V (mill finish 32 rms), were precleaned, autoclaved, and then inoculated with 10^3 viable (10^4 total) *Bacillus subtilis* spores. The inoculated coupons were then cleaned using: a standard JPL cleanroom polyester wipe wetted with 70% IPA; a standard wipe wetted with ultrapure water (UPW); detergent cleaning followed by a UHP water rinse; a standard, multiple solvent, flight hardware cleaning procedure; (FS505146); a commercial, semi-aqueous cleaning process; and a commercial, oxygen plasma cleaning method. Cleaning effectiveness was then measured using: NASA agar plate assay (NPG: 5340.1C), diffuse reflectance Fourier transform infrared spectroscopy (DRIFT, as per MIL-STD 1246C), limulus ameobocyte lysate (LAL), environmental scanning electron microscopy (ESEM), field emission SEM (FESEM), and epifluorescence microscopy.

Preliminary results show that none of the methods tested were able to completely remove spores inoculated onto Al 6061, while both the multiple solvent, flight hardware cleaning procedure and the semi-aqueous cleaning process were able to clean Ti 6Al-4V to sterility. Of the above two methods, flight hardware cleaning procedure cleaned Al 6061 more effectively than the semi-aqueous process. A detailed report on the findings of this study will be presented, including a discussion of the induced surface changes induced and their impact on cleaning effectiveness. Plans to extend our study to include a wider range of biological species will also be presented.